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Correlation between Serum Vitamin D Status and Body Mass Index in Obese Women

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Abstract: **Obesity and Vitamin D deficiency are now considered morbidity phenomenon prevalent in the whole world. Moreover, obese subjects are known to have lower vitamin D levels compared to non-obese subjects. The objectives of the current study are to estimate the prevalence of obesity and vitamin D status in women living in Jeddah, Saudi Arabia and to find the correlation between serum [25(OH)D] and BMI in Saudi women, in addition to predict the serum vitamin D status in obese women. Two hundred seventy one Saudi women, aged between 20-40 years were included with this study. Studied subjects visited the clinic of the Center of Excellence for Osteoporosis Research (CEOR), during November 2013 to September 2014 and measured their fat distribution by dual energy X-ray absorptiometry (DXA). Women were stratified according to their body mass index (BMI) into overweight with 25-<30 kg/m^2 and obese with BMI ≥30 kg/m^2. Women provided their blood samples to detect Serum [25(OH) D]: a value of < 24.9 nmol/L is considered as deficiency, insufficiency 25 to 74.9 nmol/L and sufficient ≥75 nmol/L. The results of the present study showed that obesity was estimated by 52.1% (29.2% overweight and 22.9% obese) by using BMI method. Anthropometric characteristic (height is excluded), fat distribution and body composition revealed a significant increasing at P< 0.0001. High prevalence of vitamin D deficiency and insufficiency were reported in all studied women (47.6% and 44.3%, respectively), regardless of BMI. The same finding of vitamin D deficiency and insufficiency were found when the women stratified according to their BMI, in control group (43.8% and 46.9%, respectively), overweight group (44.3% and 49.4%, respectively) and obese group (59.7% and 32.3%, respectively). Furthermore, our result showed that serum [25(OH)D] has no significant difference between the studied women in relation to their BMI unless the women were stratified according to vitamin D status into deficiency, insufficiency and sufficiency; After this stratification, a negative association was found between serum [25(OH)D] and BMI for only the sufficient group in obese women. In conclusion, the present study has demonstrated that vitamin D deficiency and insufficiency are rather highly prevalent among women living in Jeddah, Saudi Arabia; and this prevalence is becoming worse with obesity.**

Keywords: **Vitamin D- BMI- DXA- Obese- Women- Jeddah.**

I. INTRODUCTION

The hypothesis is that vitamin D deficiency is the cause of obesity and that obesity can be reversed by improving vitamin D status [1]. Many studies reported that low serum [25(OH)D] is involved in obesity [2, 3]. Obesity is a risk factor for hypovitaminosis D because obese people often have less exposure to sun exposure due to limited mobility and making less physical activity [4, 5], the possible trapping of vitamin D by the adipocytes [4, 6], fat soluble vitamin D is stored in the body fat compartments reducing its bioavailability [5, 7], the need for vitamin D for stronger bones to support their greater weight in addition to clothing habits [5].

Previous study reported that "vitamin D, obesity and obesity-related chronic disease among ethnic minorities"; they reported that ethnic minorities had substantially greater rates of vitamin D insufficiency ([25 (OH)D]<50 nmol/L) than their white counterparts[5]. Moreover, "Low vitamin D status among obese adolescents" was reported since the authors found that the prevalence rate of low vitamin D status among obese adolescents was 100% in females and 91% in males [8]. Furthermore, "Hypovitaminosis D and incidence of obesity" were reported by González-Molero and others [9]; they conclude that vitamin D deficiency had a link with obesity developing. Another study done by Vasilopoulos *et al*. [10] reported that VDR role as cause for obesity.

The objective of the present study is to estimate the prevalence of obesity and to evaluate vitamin D status through measuring serum [25(OH)D] for the total women and then for the stratified women according to the obesity category, and to find the association between serum [25(OH)D] and BMI in Saudi women living in Jeddah, in addition to predict the serum vitamin D status in obese women.

II. SUBJECTS AND METHODS

A sample size was calculated using OpenEpi. Two hundred seventy one women, aged between 20-40 years, living in Jeddah, Saudi Arabia (Latitude 21.4500 degrees North and Longitude 39.8167 degrees East) were visited a clinic of Center of Excellence for Osteoporosis Research (CEOR) in King Abdulaziz University (KAU) during November 2013 to September 2014. Participated women signed a written informed consent and completed a questionnaire concerning to demographic information, medical history, lifestyle and drug intake. The subjects should be free of all diseases that interfere with obesity. The study was approved by the Human Research Ethics Committee of CEOR, KAU and was in agreement with ethical standards of the Helsinki Declaration of 1975. Studied subjects were medically examined at CEOR clinic, provided blood samples and measured their fat distribution by dual energy X-ray absorptiometry (DXA).

ANTHROPOMETRIC MEASUREMENTS: The anthropometric characteristics are reordered; age, body weight, height, body mass index (BMI) and waist to hip ratio (WHR). The BMI was calculated as weight in kilograms (kg) per square height in meter (m^2); the weight in kg and height in centimeter (cm) were measured by a balance (Detecto, MO,USA; range of weight 0.1-180 kg and range of height 0-200 cm). The WHR was measured as waist circumference (WC) in cm divided by hip circumference (HC) in cm. The WC and HC were determined using a flexible tape (range 0-150 cm). The WHO STEPS protocol for WC measurement should be made at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest while HC measurement should be taken around the widest portion of the buttocks [11].

OBESITY CLASSIFICATION: Obesity is classified in the present study by many methods; Firstly, BMI: World Health organization (WHO) classifies normal weight between 18.5 - 24.9 kg/m^2, overweight between 25 - 29 kg/m^2, obesity ≥ 30 kg/m^2 [12, 13]. Secondly, WHR, A ratio > 0.6 in females proposes an unwanted obesity pattern [14]. Thirdly, TBF (%) >30% in women is assumed in many researches to define the obesity [15]. Abdominal Obesity was expressed by WC; women with abdominal obesity have WC > 88 cm [16]. However, BMI category was chosen to stratify the women into control, overweight and obese groups in this study.

DUAL ENERGY X-RAY ABSORPTIOMETRY (DXA): DXA displays accurate, comprehensive body composition analysis comprising bone, lean and fat tissue distribution which were assessed by using (GE Healthcare, Lunar iDXA model, USA) according to a typical procedure; data were analyzed with enCORE software (version 13.6). Women taken off all metal accessories, plastic and rubber materials that could affect the X-ray beam. Mean precision error of the daily calibration procedure was 0.7%. Manufacturer standard software provided the body fat patterning for android and gynoid regions as well as percent total body fat (TBF%), total mass (kg), percent tissue fat (%), tissue (g), fat (g), fat free (g), lean (g) and bone mineral content (BMC, g).

VITAMIN D STATUS: Serum samples were centrifuged at 3,000 g/ 15 min by (Clay – Adams, USA) centrifuge then stored at -80°C until examined the serum [25 (OH)D]. [25(OH)D] kit was obtained from DiaSorin Inc, Stillwater, MN, USA and measured by using LIASON autoanalyzer. As per the Clinical Diagnostics Laboratory at CEOR, intra- and inter- assay coefficients of variance (CVs) were 7.8% and 3.8%, respectively, for serum [25(OH)D]. Functional sensitivity of the assay was ≤ 9.984 nmol/L, according to the manufacturer information sheet. Results are expressed as nmol/L. Vitamin D status is assessed by serum [25(OH) D] [17]. In this study, the cut-offs for vitamin D deficiency was adopted from Spiro and Buttrissas [18] as the following; deficiency: a value of < 24.9 nmol/L, insufficiency: 25 to 74.9 nmol/L and adequate or sufficient: ≥ 75 nmol/L.

STATISTICAL ANALYSIS: Statistical analysis of the data was carried out using computer program package (SPSS, version 22). One-Way ANOVA test was used to examine differences among the groups for different variables. A relationship between vitamin D status and BMI was assessed by Bivariate Pearson correlation analysis. Differences were considered significant at *P* <0.05.

III. RESULTS

Prevalence of obesity was presented in Table 1. By using BMI (kg/cm^2) method; it was estimated by 52.1% (29.2% overweight and 22.9% obese) while it was displayed as 96.7% by TBF (%) and 100% by WHR scale. Abdominal obesity was evaluated 28.8% by using WC (cm) scale.

Table 1 Prevalence of Obesity in the Studied Women

Method	Prevalence
BMI (kg/m^2)	52.1% (29.2% overweight and 22.9% obese)
%TBF	96.7%
WHR	100%
WC (cm)	28.8%

BMI: body mass index; TBF: total body fat; WHR: waist to hip ratio; WC: waist circumference

Anthropometric characteristics of the studied women were shown in Table 2. The women divided according to their obesity category into control, overweight and obese groups. The results showed logically significant increasing in weight (kg), BMI (kg/m^2), HC (cm), WC (cm) and WHR between the studied groups, P< 0.0001.

Table 2 Anthropometric Characteristics of the Women

Variables	Control (n= 130)	Overweight (n= 79)	Obese (n= 62)	P-value
Weight (kg)	53.1 ± 6.8	67.7 ± 5.5	85.7 ± 11.8	0.0001***
Height (m)	1.6 ± 0.1	1.6 ± 0.1	1.6 ± 0.1	0.913
BMI (kg/m^2)	21.3 ± 2.5	27.3 ± 1.5	34.3 ± 3.7	0.0001***
HC (cm)	94.4 ± 6.5	105.3 ± 5.1	116.8 ± 7.7	0.0001***
WC (cm)	73.25 ± 7.5	86.0 ± 6.3	98.4 ± 9	0.0001***
WHR	0.8 ± 0.1	0.8 ± 0.1	0.8 ± 0.1	0.0001***

Values are presented as means±SD; BMI: body mass index; HC: hip circumference; WC: waist circumference; WHR: waist to hip ratio; *** Highly significant P< 0.0001.

The fat distribution and body composition were evaluated in Table 3. This table showed highly significant increasing in all studied parameters between control, overweight and obese groups; total mass (kg), tissue (%fat), tissue (g), fat (g), fat free (g), lean (g), fat region (%), android, gynoid, Android to Gynoid (A/G) ratio and TBF (%) at P< 0.0001 while BMC (g) was significant at P< 0.05.

Table 3 Body Composition and Fat Distribution of Women

Variables	Control (n= 130)	Overweight (n= 79)	Obese (n= 62)	P-value
Total Mass (kg)	52.2 ± 6.7	67.276 ± 5.9	83.941 ± 11.64	0.0001***
Tissue (%Fat)	38.7 ± 5.1	46.046 ± 4	50.330 ± 4.31	0.0001***
Tissue (g)	50224.61 ± 6534.12	65158.98 ± 5865.24	81759.85 ± 11351.1	0.0001***
Fat (g)	19662.21 ± 4536.45	30145.43 ± 4128.56	41403.79 ± 8152	0.0001***
Fat Free (g)	32521.60 ± 3291.64	37189.65 ± 3523.74	42542.66 ± 5222.88	0.0001***
Lean (g)	30559.81 ± 3137.24	35004.02 ± 3337.84	40232.73 ± 5017.98	0.0001***
BMC (g)	1960.86 ± 217.17	2340.97 ± 2011.76	2309.92 ± 281.43	0.025*
Region (%Fat)	37.29 ± 5.02	44.640 ± 3.7	49.081 ± 4.18	0.0001***
Android	34.4 ± 8.5	47.1 ± 5.6	54.3 ± 5.5	0.0001***
Gynoid	45.7 ± 5.1	51.9 ± 4	53.9 ± 4.6	0.0001***
A/G ratio	0.7 ± 0.1	0.9 ± 0.1	1.0 ± 0.1	0.0001***
TBF (%Fat)	38.7 ± 5.1	46.0 ± 4	50.3 ± 4.3	0.0001***

Values are presented as means±SD; BMC: bone mineral content; A/G ratio: android to gynoid ratio; TBF: total body fat; * Significant P< 0.05; *** Highly significant P< 0.0001.

Vitamin D status was shown in Table 4 and Fig. 1. Highly prevalence of vitamin D deficiency and insufficiency as expressed by (serum [25(OH)D] <24.9 and 25-74.9 nmol/L, respectively) were reported in all studied women (47.6% and 44.3%, respectively), regardless of BMI. The same finding of vitamin D deficiency and insufficiency were found when the women after stratified to their BMI, in control group (43.8% and 46.9%, respectively), overweight group (44.3% and 49.4%, respectively) and obese group (59.7% and 32.3%, respectively). Fig. 2 illustrated the boxplots for serum [25(OH)D], the line in the middle of boxplot indicated the value of the median value and the small circles and stars reflect the outliers in the data.

Table 4 Vitamin D Status in Control, Overweight and Obese Women

		[25(OH)D] Deficiency (<24.9 nmol/L)	[25(OH)D] Insufficiency (25-74.9 nmol/L)	[25(OH)D] Sufficiency (≥75 nmol/L)	
Control	no. of cases	57	61	12	130
	%	43.8%	46.9%	9.2%	100.0%
Overweight	no. of cases	35	39	5	79
	%	44.3%	49.4%	6.3%	100.0%
Obese	no. of cases	37	20	5	62
	%	59.7%	32.3%	8.1%	100.0%
Total	no. of cases	129	120	22	271
	%	47.6%	44.3%	8.1%	100.0%

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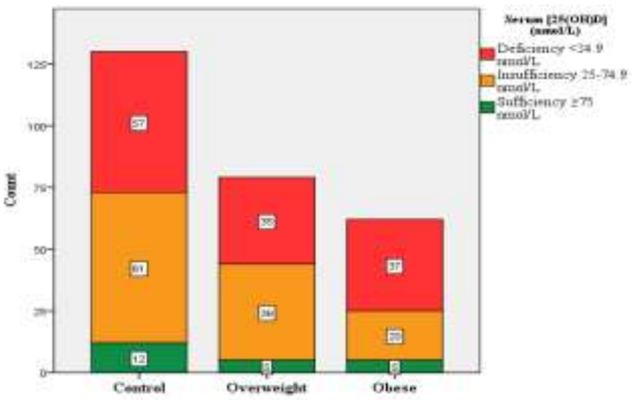

Figure 1 Vitamin D Status between Studied Groups

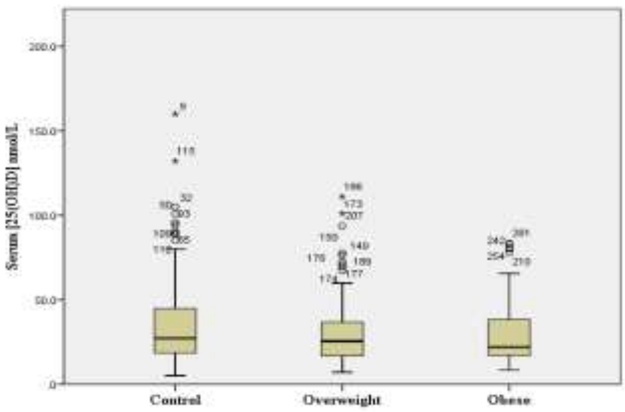

Figure 2 Boxplots for Serum [25(OH)D]

Note that the line in the middle of the boxplot indicates the value of the median value and the small circles and stars reflect the outliers in the data

Serum [25(OH)D] has no significant difference between the studied women in relation to their BMI, this result suggested the possibility to classify our data to three categories according to their vitamin D level (deficiency, insufficiency and sufficiency) as serum [25(OH)D] (<24.9, 25-74.9 and ≥75 nmol/L, respectively), to check the relationship between serum [25(OH)D] and BMI in each category of obesity.

After stratification of vitamin D status, there was a negative association between serum [25(OH)D] and BMI for only the sufficient group in obese women, Fig. 3.

This relationship can be expressed by mathematical exponential equation (1) at P-value = 0.033:

$$BMI = 43.575 * e^{-0.005\,[25(OH)D]} \quad (1)$$

The same equation can be written as linear model (2):

$$Ln\,(BMI) = 3.774 - 0.005\,[2(OH)D] \quad (2)$$

Where Ln (BMI) is the natural logarithm of BMI

By using this predictive model, we can predict the vitamin D level from the BMI of the woman and the opposite is correct. To apply and check the accuracy of the predictive model, a new volunteer (out of the studied women who used to obtain the model) with serum [25(OH)D] equal to 44.9 nmol/L was used to predict BMI. The predicted value for the BMI was found to be 30.59 kg/m2. The true value for the BMI for this volunteer was equal to 31.20 kg/m2. This means that the error for estimating equals to 0.61 kg/m2 only, which gives an idea about the accuracy of the model and how we can use it to predict the BMI.

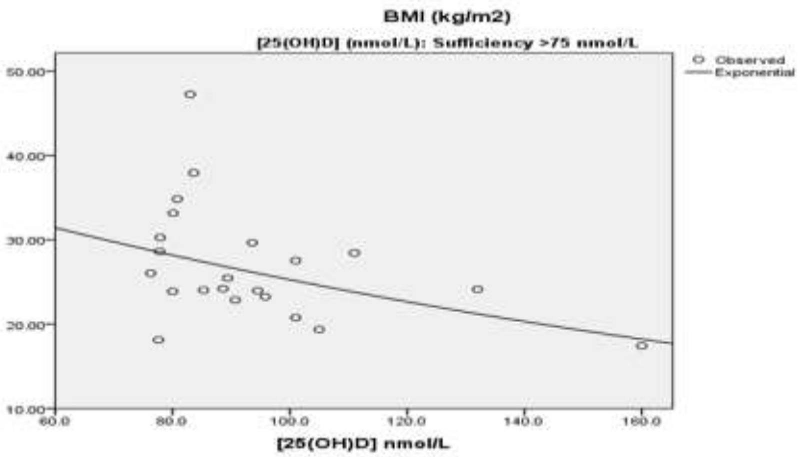

Figure 3 Relationship between sufficient serum [25(OH)D] and BMI in the studied women

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IV. DISCUSSION

Common obesity has become prevalent in recent decades; overweight and obesity are considered as major public health problems [1, 19, 20]. Our results showed prevalence of obesity as defined by BMI (29.2% overweight and 22.9% obese), by TBF (96.7%) and by WHR (100%) of studied women. This growth of overweight and obesity may be due to increasing in population size and total calorie intake, in addition to physical activity reduction in Saudi Arabia [21, 22].

The prevalence of overweight and obesity were demonstrated in previous studies. WHO [20] reported that 39% of adults were overweight and 13% were obese in 2014. Kelly *et al.* [19] evaluated a prevalence overweight was 23.2% (women 22.4%) and obesity was 9.8% (women 11.9%) in the world and in various regions. In the Mediterranean regions, prevalence of excess weight (overweight and obesity) has been increased especially in women [23]. In Saudi Arabia, Al-Nozha *et al.* [24] were reported the prevalence of overweight was 36.9% (females 31.8%) and prevalence of obesity was 35.5% (females 44%). By 2030, the prevalence of overweight and obesity are predicted to increase (38% and 20%, respectively) [19].

The results of the current study showed a logically significant increasing in all anthropometric characteristic (height is excluded), fat distribution and body composition caused by weight gain resulted from fat mass accumulation that increases in body size [1].

A highly prevalence of vitamin D deficiency and insufficiency were shown in present study with or without overweight or obesity. This prevalence may be explained by traditional lifestyles and Islamic clothing that covered skin from sun exposure since vitamin D is considered as a photoreceptor retained the UVB radiation [1, 25-27], or may be due to race and ethnicity [28], moreover, foods are too low in vitamin D amount to achieve a [25(OH)D] level of 75 nmol/L [26].

This finding was consistent in several studies around the world; Van Schoor and Lips [29] reported that vitamin D deficiency has a high prevalence over the world; they determined risk factors for vitamin D deficiency as low sun exposure, skin pigmentation, sunscreen use, skin covering clothes and a diet low in fish and dairy products. In other study done by Zittermann and Gummert [26] concluded that insufficient vitamin D status is prevalent in Asia, Europe, Middle East and Africa, Latin America, North America, and Oceania–through a survey of published literature. Depending on the region, between 50% and more than 90% of people had [25(OH)D] concentrations below 50 nmol/L. In Europe and Asia, vitamin D status was stated by Lips [30] who concluded that vitamin D deficiency is common in Southern Europe, the Middle East, India, China and Japan. It is less common in Northern Europe and Southeast Asia. He demonstrated that important factors are skin type, sex, clothing, nutrition, food fortification, supplement use, BMI and degree of urbanization. In Saudi Arabia, Qari *et al*. [31] confirmed vitamin D deficiency among healthy Saudi pre- and postmenopausal women that is attributed to obesity, poor exposure to sunlight, poor dietary vitamin-D supplementation and age. Another study done in Saudi Arabia, Akbar and others [32] reported severe vitamin D deficiency is associated with decreased circulating endothelial progenitor cells and endothelial dysfunction in patients with Type 2 diabetes mellitus. Hussein *et al.* [33] reported Obesity was more prevalent among the postmenopausal women. They found that total of 30.7% of the women were overweight and 38.5% were obese. They suggested that obesity is associated with vitamin D insufficiency is likely due to the decreased bioavailability of vitamin D3.

Although, this inverse association between vitamin D deficiency and obesity was demonstrated in many researches [5, 6, 8, 34, 45], our result didn't show a statistical difference between vitamin D deficiency and body weight. This discrepancy may be due to race or population, additionally, all studied women (control, overweight or obese) were suffering from vitamin D deficiency and insufficiency.

However, the hypothesis of a negative relationship between serum [25(OH)D] and BMI was achieved after classifying our data to three categories according to their vitamin D level (deficiency, insufficiency and sufficiency) as serum [25(OH)D] (<24.9, 25-74.9 and ≥75 nmol/L, respectively), After this stratification, a negative association was presented for the sufficient group in obese women and this relation was exhibited as mathematical equation which let us unable to predict the woman BMI from the her vitamin D level or predict the vitamin D level from her BMI.

The possible mechanisms that explain this link between obesity and serum [25(OH)D] are; reduced bioavailability of cholecalciferol for its kidnapping in body fat tissue [17, 33], ethnic and gender [5], decreased exposure to sunlight because of limited mobility or cosmetic problems [7, 16, 36]. Furthermore, many parameters were not measured in this study which can explain the negative relation between vitamin D and BMI such as a negative feedback from elevated

1,25(OH)D and parathyroid hormone levels [36], insulin resistance [1, 6, 27], vitamin D receptor (VDR) [1, 10], season variation [7, 17] and exercise and physical activity [17, 37].

Limitations of this study included it did not take into consideration the physical activity, smoking, demographic characteristics, pregnancy, multiparity, metabolic parameters, season variation, sun exposure and vitamin D supplementation.

In conclusion, the present study has demonstrated that vitamin D deficiency is rather highly prevalent among Saudi women living in Jeddah and this prevalence is becoming worse with obesity. It seems obvious that further studies, vitamin D supplementation and awareness program are needed to overcome vitamin D deficiency or insufficiency in Saudi women.

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